

The mangrove and its conservation in Leizhou Peninsula, China

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Abstract: Leizhou Peninsula, located at southern end of mainland China, has 9 284.3 ha mangrove distributed more than 100 sites along its inlets and open coastlines. This paper presents the surveys on mangrove area in Leizhou Peninsula during 2000 and 2008, especially the survey in the eight major mangrove areas in 2002. The flora recorded in mangrove systems includes 69 large algae species, 13 native true mangrove species, nine native semi-mangrove species, and another seven introduced true mangrove species with *Sonneratia apetala* as the quickest growing exotic mangrove species dominant in the mangrove plantations, and more than 100 land flora species, consisting of 17 main mangrove associations. The plant biodiversity habitats remained mainly small patches and diverse, and were becoming worse under the intensive disturbance of human activities and coastal pollutions, which decreased the value of mangrove coasts as the important sites for flying-by migrating birds in Leizhou Peninsula. The effective mangrove conservation measures should be implemented.

Keywords: conservation; flora; Leizhou Peninsula; mangrove

Introduction

Leizhou Peninsula, administratively named Zhanjiang city, is situated at the most southern tip of mainland China, with longitude 109°30'–110°55'E and latitude 20°12'–21°35'N. Two main rivers around the land are Jianjiang ending at Zhanjiang Bay in the east and Jiuzhoujiang ending at Beibo Bay in the west, respectively. Nandou River developed in the northern lowlands ends at Leizhou Bay in the middle east of the land. Another more than 42 small rivers also end to the coastal seawater. Including neighbouring islands, Leizhou Peninsula has 1 556 km coastline and 99 000 ha intertidal zone. More than 100 bays distribute along the coastlines, of which Zhanjiang Bay is the biggest bay with an area of 1 419 km², followed by Leizhou Bay with an area of 867 km². Leizhou Peninsula has a northern tropic monsoon climate with annual mean temperature of 22.3°C. The coldest and hottest days are in January and July, respectively. The annual accumulated temperature $\geq 10^{\circ}\text{C}$ is higher than 8 000°C. The mean lowest temperature in decades is higher than 11°C. Rain season ranges from May to September, but the rainfall distribution is uneven, with the characteristics of more rainfall

in the northeast and less in the southwest. Typhoon arrives frequently during summer days on the eastern coastline. The intertidal zones of Leizhou Peninsula mainly consist of sandy beaches, wetlands and mudflats only at coastal inlets or mouths of rivers where mangroves grow in big area or in small patches. The east coast tides appear every half-day while the west coast tides appear every whole day. Wind waves occupy 80% of all kinds of water waves while swelling wave rates only 20%. The most frequently happening waves belong to grade three as the waves above grade five seldomly happen. Meanwhile the coastal water surface could rise higher than 1 m with 45.5% frequency after typhoon (Chen 1999). The intertidal water depth varies between 3.52 m and 1.77 m at Laozhou Oceanic Observation Station during the years of 1962–1991, while the data became higher towards its southern tip (GCST 1987). There are mainly *Eucalyptus*, *Acacia* and *Casuarina equisetifolia* plantations on the land areas besides the secondary monsoon rain forests and cultivated *Litchi* and *Longan* gardens. The land has the largest continuously distributed mangrove area among all the mangrove areas in China, although mangroves have been destroyed along the most parts of the coasts for aquaculture.

This article presents the surveys on mangrove area in Leizhou Peninsula during 2000 and 2008, especially the survey in the eight major mangrove areas in 2002 as well as other research data collected.

Mangrove distribution

The total mangrove area in world is about 17 000 000 ha, mainly distributing in tropical countries such as Brazil and Indonesia. In China, mangroves distribute along the eastern to southern coastlines of China from the most northern distributional tip in Zhoushan, Zhejiang to the most southern distributional tip in Sanya, Hainan and some isles in China South Sea (Lin 1997).

Foundation project: This study is supported by GDOU: 0717112; GDSTC: 2008A0303007; NSFC: 20376086/ B060407.

Received: 2009-02-06; Accepted: 2009-04-02

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The online version is available at <http://www.springerlink.com>

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Responsible editor: Hu Yanbo

In total 7 242 ha of mangroves in Leizhou Peninsula excluding 25.6 ha of newly planted mangroves, 509.4 ha of naturally regenerated young mangroves and other 9 688.6 ha of intertide area suitable for mangrove reconstruction were recorded during the national mangrove resource survey in 2001 (Lin Kangying 2002). The mangrove area recorded by local governments was 7 305.8 ha (Table 1) in 2001, comprising 33% of total mangrove area in China and 80% in Guangdong Province. The mangrove areas involve more than 100 sites along the China coastline, mainly distributing in Gaoqiao, Beitan, Qishui, Maicheng and Wuli in the west and Techeng and Xinhua in Zhanjiang Bay, Taiping, Fucheng and He'an in Leizhou Bay in the east (Fig. 1).

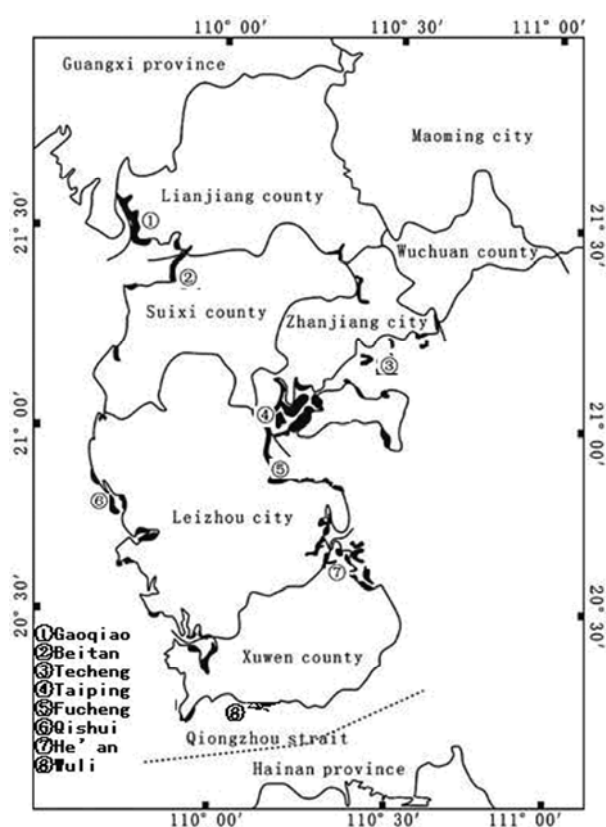


Fig. 1 The mangrove distribution in Leizhou Peninsula in 2008. Black shading denotes mangrove areas.

In 2007, the mangrove area in Leizhou Peninsula was 9 284.3 ha, with an increment of 27.08% as compared with that in 2001 (Table 1). The mangrove area in Leizhou Peninsula once reached 14 027 ha in 1956, but subsequently it decreased to 5 800 ha in 1985 because of over cutting for firewood and manual as well as turning sea beaches into rice fields and fish/shrimp pools (aquaculture). After 1985, the importance of mangrove wetlands has been recognized. Important mangrove reserves were established in succession last years. For example, the Gaoqiao Mangrove Natural Reserve was set up in 1990, with mangrove area of 1 361.6 ha within its protected area of 2 249.4 ha. Zhanjiang Mangrove National Natural Reserve was set up on Oct. 8, 1997 for the conservation of mangrove ecosystems, with protected area of 20 279 ha covering most mangrove areas in

Leizhou Peninsula. Thereafter, 'mangrove resource management regulations of Zhanjiang City' was issued by Zhanjiang municipal government on March 3, 2001 and mangrove planting along coastal Leizhou Peninsula has become one of important tasks of local authorities. In total 1 200 ha of mangrove was planted by local communities during 1985–1990 and then another 1 000 ha of plantations were planted by the project of Sino-Dutch Integrated Mangrove Management and Coastal Protection (IMMCP) during 2001–2007 (Qu 2006).

Table 1. The changes of mangrove area in Leizhou Peninsula between 1993 and 2007 (ha).

Distribution	1993	2001	2007	Area change %	
				1993–2001	2001–2007
Shashan	-	50.7	44.3	-	-12.62
Potou	700.7	210.1	467.4	-70.02	+122.47
Mazhang	2798.6	1986.8	2246.1	-29.01	+13.05
Donghai Island	2895.4	1475.3	1363.3	-49.05	-7.59
Wuchuang	No data	75.6	88.8	-	+17.46
Xuwen	1097.8	726.9	1018.9	-33.79	+40.17
Leizhou	2132.1	1064.6	1190.8	-50.07	+111.85
Suixi	516.1	354.2	488.2	-31.37	+37.83
Lianjiang	2282.2	1361.6	2376.5	-40.34	+74.54
Total	12422.9	7305.8	9284.3	-41.19	+27.08

The plant species in mangrove systems

The large algae

Large algae are common found in the mangrove areas in Leizhou Peninsula. To date, 69 species of large algae were found by our field investigation in past 5 years as shown in Table 2, of which *Monostroma nitidum*, *Gracilaria tenuistipitata*, *Enteromorpha compressa* and *E. clathrata* were about blooming species and covered the mangrove coasts in Leizhou Peninsula with green from February to March.

The mangrove species and mangrove companion species

In total 37 mangrove species have been identified in China, belonging to 21 families and 25 genera (Chen Guikui 1998; Lin 1997; Lu and Ye 2006). Based on the author's field investigation for last 10 years, 22 species, including 13 true mangrove species and nine semi-mangrove species, are found in Leizhou Peninsula and they have great importance in coastal ecosystem conservation as native biodiversity listed in Table 3 (Han 2003; Han and Gao 2003). Moreover, more than 54 species from 27 families are growing as the companion species of native high plant collected in the mangrove ecosystems, of which 32 common companion species were listed in Table 4.

Seven introduced mangrove species are listed as follows: *Bruguiera sexangula*, *Rhizophora apiculata*, *Xylocarpus granatum*, *Sonneratia alba*, *S. apetala*, *S. caseolaris*, *S. hainanensis*. *S. apetala* and *S. caseolaris* are promoted by large scale reforestation in Leizhou Peninsula, indicated by their fast

growth characteristics and good adaptation to environments. The species can provide excellent arbor mangrove landscapes to meet ecological sheltering demands, as most of the mangroves are dwarf with less than 4 m high in Leizhou Peninsula.

Table 2. List of large algae species growing in mangrove in Leizhou Peninsula

Species	Species
1. <i>Acetabularia caliculus</i>	36. <i>Gloiopeltis tenax</i>
2. <i>Acetabularia mobii</i>	37. <i>Gracilaria tenuistipitata</i>
3. <i>Boergesenia forbosii</i>	38. <i>Gymnogongrus flabelliformis</i>
4. <i>Brachytrichia quoyi</i>	39. <i>Hormophysa articulate</i>
5. <i>Bryopsis harveyana</i>	40. <i>Hypnea cornuta</i>
6. <i>B. plumosa</i>	41. <i>Laurencia chinensis</i>
7. <i>Caloglossa leprieurii</i>	42. <i>Lobophora variegata</i>
8. <i>Carpopeltis angusta</i>	43. <i>Lyngbya semiplena</i>
9. <i>C. maillardii</i>	44. <i>Laurencia</i> sp.
10. <i>Caulerpa okamurai</i>	45. <i>Mastophora rosea</i>
11. <i>Ca.peltata</i>	46. <i>Monostroma nitidum</i>
12. <i>Ca.prolifera</i>	47. <i>Neomeris annulata</i>
13. <i>Ca.taxifolia</i>	48. <i>Pachydictyon coriaceum</i>
14. <i>Ceratophyllum demersum</i>	49. <i>Padina australis</i>
15. <i>Chaetomorpha</i> sp.	50. <i>Porphyra suborbiculata</i>
16. <i>Chondria armata</i>	51. <i>Pterocladia tenuis</i>
17. <i>Cladophora aokii</i>	52. <i>Sargassum angustifolium</i>
18. <i>Cl. fascicularis</i>	53. <i>S. capilliforme</i>
19. <i>Cl. japonica</i>	54. <i>S.cinereum</i>
20. <i>Cl. rugulosa</i>	55. <i>S. coriifolium</i>
21. <i>Cl. sp.</i>	56. <i>S.hemiphyllum</i> var. <i>chinensis</i>
22. <i>Cladophoropsis fasciculatus</i>	57. <i>S. henslowianum</i>
23. <i>Cl. zollingeri</i>	58. <i>S. integerrimum</i>
24. <i>Co.abhaerens</i>	59. <i>S.fruticulosum</i>
25. <i>Co.cylindricum</i>	60. <i>S.hemiphyllum</i>
26. <i>Co.repens</i>	61. <i>S.naozhouense</i>
27. <i>Colpomenia sinuosa</i>	62. <i>S.swartzii</i>
28. <i>Dictyosphaeria spinifera</i>	63. <i>S.vachellianum</i>
29. <i>Dictyota friabilis</i>	64. <i>Siphonocladus tropicus</i>
30. <i>D. linearis</i>	65. <i>Symploca hydroides</i>
31. <i>Enteromorpha flexuosa</i>	66. <i>Ulva conglobata</i>
32. <i>E. clathrata</i>	67. <i>Valonia aegagropila</i>
33. <i>E. compressa</i>	68. <i>V. ucrularis</i>
34. <i>Galaxaura pacifica</i>	69. <i>Valoniopsis pachynema</i>
35. <i>Gelidium crinale</i>	

Table 3. Native mangrove species in Leizhou Peninsula

True Mangrove species	Semi-Mangrove Species
1. <i>Acanthus ebrectearus</i>	1. <i>Cerbera manghas</i>
2. <i>Acanthus ilicifolius</i>	2. <i>Clerodendron inerme</i>
3. <i>Acrostichum aureum</i>	3. <i>Hibiscus tiliaceus</i>
4. <i>Acrostichum speciosum</i>	4. <i>Pluchea indica</i>
5. <i>Aegiceras corniculatum</i>	5. <i>Pongamia pinnata</i>
6. <i>Avicennia marina</i>	6. <i>Premna obtusifolia</i>
7. <i>Bruguiera gymnorrhiza</i>	7. <i>Scaevola sericea</i>
8. <i>Ceriops tagal</i>	8. <i>Thespea populnea</i>
9. <i>Excoecaria agallocha</i>	9. <i>Vitex trifolia</i> var. <i>simplicifolia</i>
10. <i>Heritiera littoralis</i>	
11. <i>Kandelia candel</i>	
12. <i>Lumnitzera littorea</i>	
13. <i>Rhizophora stylosa</i>	

Table 4. The common mangrove companion species in Leizhou Peninsula

Species	Species
1. <i>Abutilon indicum</i>	17. <i>Rhodymyrtus tomentosa</i>
2. <i>Bambusa stenostachya</i>	18. <i>Myoporum bontiodides</i>
3. <i>Bridelaia tomentosa</i>	19. <i>Pandanus tectorius</i>
4. <i>Canavalia maritima</i>	20. <i>Phoenix hanceana</i>
5. <i>Cassytha filiformis</i>	21. <i>Phragmites australis</i>
6. <i>Chorisis repens</i>	22. <i>Scaevola hainensis</i>
7. <i>Cynodon dactylon</i>	23. <i>Scolopia saeva</i>
8. <i>Cyperus malaccensis</i> var. <i>brevifolius</i>	24. <i>Sesuvium portulacastrum</i>
9. <i>Derris trifoliata</i>	25. <i>Spinifex littoreus</i>
10. <i>Eleocharis acutangula</i>	26. <i>Sporobolus virginicus</i>
11. <i>Erythrina variegata</i>	27. <i>Suaeda crassifolia</i>
12. <i>Flacourtia indica</i>	28. <i>Trianthema portulacastrum</i>
13. <i>Gymnanthera oblonga</i>	29. <i>Tylophora arenicola</i>
14. <i>Halophila ovalis</i>	30. <i>Wedelia chinensis</i>
15. <i>Ipomoea pes-caprae</i>	31. <i>Wikstroemia indica</i>
16. <i>Kochia scoparia</i> var. <i>sieversiana</i>	32. <i>Zoysia matrella</i>

The mangrove associations

In total 59 mangrove associations were recorded in the national mangrove resource survey in 2001. All the species listed in Table 3 are dominant species in some mangrove coasts between middle and high tidelines, namely forming single dominant species of mangrove association. About 17 main mangrove associations in Leizhou Peninsula are listed as follows: Ass. *Acrostichum aureum*; Ass. *Avicennia marina*; Ass. *Aegiceras corniculatum*; Ass. *Rhizophora stylosa*; Ass. *Kandelia candel*; Ass. *Bruguiera gymnorrhiza*; Ass. *Excoecaria agallocha*; Ass. *Avicennia marina* + *Rhizophora stylosa*; Ass. *Avicennia marina* + *Aegiceras corniculatum*; Ass. *Rhizophora stylosa* + *Kandelia candel*; Ass. *Kandelia candel* + *Aegiceras corniculatum*; Ass. *Heritiera littoralis* + *Cerbera manghas*; Ass. *Ceriops tagal*; Ass. *Hibiscus tiliaceus*; Ass. *Cerbera manghas*; Ass. *Scaevola sericea*; Ass. *Sonneratia apetala*. Among them, Ass. *Avicennia marina* is the widest distributed mangrove type in Leizhou Peninsula, with a total area of 1228.9 ha, followed by Ass. *Aegiceras corniculatum* with a total area of 860.5 ha. The populations of *Aegiceras corniculatum*, *Avicennia marina*, *Rhizophora stylosa* and *Kandelia candel* were clumpy distributed while the population of *Bruguiera gymnorrhiza* with the distribution of poisson (Miao 1998). Ass. *Sonneratia apetala* as an exotic plantation was first introduced in Leizhou Peninsula in 1993 and the oldest stands planted at Fucheng, Leizhou County in 1995 had a canopy with the largest trees with diameter at breast height (DBH) of 21 cm and leaf area index (LAI) 9.0 and coverage 90%, indicating that the species is the quickest growing mangrove species. During 1995–2007, more than 1 000 ha of the plantation was planted.

Particularly, three rare mangrove associations are becoming endangered:

(1) Ass. *Ceriops tagal*. The rare mangrove association has the living space only less than 1 ha found at high tideline of Maicheng, the southwestern inlet of Leizhou Peninsula, with

intertide water depth 0.5–1 m. The reddish green canopy is 1.3–2.5 m high with coverage at 40–95%. The association is in relic state and is endangered with the pressure of shrimp pool construction from its three surrounding sides.

(2) Ass. *Cerbera manghas*. Small patches distributed along high tideline coasts in Leizhou Peninsula; each patch usually in 6 m × 4 m with 5–11 plants with DHB at 5.0–6.0 cm, canopy height at 2.8–3.5 m, with many land species growing as companion species.

(3) Ass. *Scaevola sericea*. A large belt found at eastern coast in Dongtoushan Isle and small patches distributed along other high tideline coasts in Leizhou Peninsula. The belt in Dongtoushan Isle is 1 000 m long and 3–10 m wide with canopy height of 0.8–1.8 m and coverage at 60–90%, 3–14 plants/m², with many land flora species growing as companion species.

The mangrove associations were mostly distributed along dikes and coastline inlets, and their habitats were in small patches and diverse, except for several large mangrove areas such as in Gaoqiao and He'an.

The mangrove conservation

The conservational values of mangrove areas as biodiversity habitats

Mangrove ecosystem conservation have high significance as important wetland resources and biodiversity habitats, since it provides great contribution in composition of complex habitats and abundant food for other biota and human being as well (Rönnbäck 1999). The complexity of mangrove and its habitats have great importance to the related fauna diversity and their distribution. For instance, the deforestation of mangrove caused decreasing of benthic biodiversity.

Since the wide distribution at more than 100 sites along the coastal Leizhou Peninsula, the mangroves have only contributed very small part to the local community economic interest except for some coastal villages where the villagers obtain benefit from it for protecting typhons or obtaining life's necessities. Therefore, the most mangrove wetlands are in pressure of being transferred into aquacultural pools or other economic fields, although Zhanjiang Mangrove National Nature Reserve Bureau was set up for protecting the mangrove resources in 2006.

In the passed decade, through the implementation of IMMCP and other conservational efforts, the public are aware of the conservational values of mangroves, but illegal activities, like fishing, hunting for birds and digging for sandworms, mudcrabs and shellfish still occurs frequently in the mangrove areas. We should make great efforts to reinforce conservational education along the mangrove coasts.

Improvement of habitat management

The law enforcement for the mangrove conservation still faces great challenges due to the following factors: (1) The traditional direct use of the mangrove resources is popular by the local coastal villagers; (2) Lack of human resource from Zhanjiang

Mangrove National Nature Reserve Bureau to carry out in-site monitoring and conservational management for its scattered 68 sub-reserve areas in Leizhou Peninsula; (3) Lack of governmental coordination since a mangrove coastal area administration involves integrated efforts of several separated administrative departments; (4) Public awareness in not eating wildlife calls more conservation education, (5) Short of hi-tech equipments and funding.

In addition, the coastal pollution causes great risk in transferring the suitable habitats into unfriendly sites for dwelling of the mangrove biodiversity.

High arbor mangroves, for instance, the plantations of *Sonneratia apetala* should be cultivated for birds dwelling, as it also provided protection for restoration of native mangrove species (Ren 2007), while the too dense mangroves should be thinned by cutting for shellfish dwelling based on the association's space structure and in-site biodiversity monitoring conclusion.

The selective exploration of mangrove resource

The mangrove resource conservation has priority to any other kinds of the economic exploration. Stopping losses of mangrove habitat and tidal flats is the top priority measure for shorebird conservation as well as for other biodiversity (Zhou 2008). The mangrove areas suitable for eco-aquaculture of mudcrab, sandworm, economic shellfish and fish species should be wisely planned and monitored in order to not finally transfer the ecological sites into market income generating fields. The mangrove ecosystems have great potential for food and medicine, and could be explored in promoting the market value of itself resource (He 2002; Lu 2006). We should pay attentions to the chemistry and bioengineering of mangrove biodiversities and ecosystems in order to find high value usage of mangrove resources in man made way under the condition of undisturbing the original mangrove ecosystems. For example, the fruits of *A. marina* can be collected as a kind of vegetable and traditional medicine in mangrove distributing coasts in South China (Han and Huang 2007). Moreover, the chemistry usage of the fruits would have great potential in market value; therefore it should be explored in the way of unaffected the natural mangrove ecosystems.

The present fishing gears used tend to become smaller in net mesh and more and more frequently in practice in mangrove areas or the nearby seawaters. Therefore, the applied fishing gear and their technological parameters used by local mangrove coastal communities should be under supervision according to the related international regulations. The electric equipments found in use for fishing in some mangrove areas should be banned (Ye 2007).

Studies on the biodiversity of endangered species

The coastal pollution and biodiversity capture have resulted in the most species of mangrove ecosystem to be endangered in Leizhou Peninsula (Han and Liu 2003). With the development of

coastal economy, coastal water quality is becoming worse, as the result, the number of dwelling biota species in each of the mangrove area was decreasing as shown in 2002 survey and later monitoring in Gaoqiao in 2005 and 2006 (Ye 2007). More than half of the fish and shellfish species in mangroves were in a few number individuals each captured. While the species with abundant individuals captured were of less economic value or invasive species (Han and Liu 2003; Tang 2007). We must make great efforts to conserve the mangrove systems, and to reverse the worsening trend. If we continue to ignore increasingly damaged behaviour like the runing of the national largest (10 million ton/year production) steel manufacture in Donghai Island and the pulp manufacture with pulp production of 0.75 million tons annually in Taiping, about 10 years later, more than half of the present mangrove biodiversity would disappear in mangrove coasts in Leizhou Peninsula. The value of mangroves as key habitats for flying-by birds and other biota would decrease greatly.

Conservation of endangered species in the mangrove areas is urgent issues. The law enforced fishing ban also should be applied in mangrove areas during June and July of each year. A special national key scientific project should be planned for the study on biodiversity in mangrove areas in Leizhou Peninsula. The hydrological conditions of mangrove areas should be analysed and the eco-engineering plan for mangrove rehabilitation should be outlined in combination of the coastal developments.

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